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Prediction of Basic Commodity Prices at the Cooperative, SME, and Trade Office Using the Least Squares Method

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ABSTRACT

The Cooperatives, Small and Medium Enterprises (SME), and Trade Office is responsible for managing national affairs related to maintaining the prices of basic commodities, including the implementation of technical instructions and regulations. A significant issue faced by the office is the lack of accessible information on estimated prices of basic commodities for both the public and government. This gap primarily stems from the absence of an information system in the Pematang Siantar City area capable of publishing these estimates. The purpose of this study is to design and develop a web-based system for predicting basic commodity prices, which will record annual price fluctuations for various basic commodities at the Cooperative, SME, and Trade Office. The findings of this study will provide policymakers with a better understanding of commodity prices in traditional markets within Pematang Siantar City, serving as a foundation for future price estimations. This is particularly relevant for market operations aimed at controlling unreasonable price increases. The Least Squares method was employed to calculate the estimated prices, with the system achieving a Mean Absolute Percentage Error (MAPE) of 14.20%, indicating that the system can predict market prices with a reasonable degree of accuracy.

I. INTRODUCTION

The current development of Information Technology has influenced various aspects of human life in carrying out daily activities [1]. The continuous advancement of technology is a crucial factor in supporting various activities, including business operations and other endeavors [2]. In the future, technological advancements will bring limitless potential, enabling the creation of new solutions to global challenges and ushering in an era of unprecedented innovation. One way to utilize this is through the use of computers as communication tools and software for various activities [3].

The Cooperative and Small and Medium Enterprises Office in Pematang Siantar City, located at X24X+5PH Bar, Simarito, West Siantar District, Pematang Siantar City, North Sumatra, Indonesia, with postal code 21111, has the primary function of regulating and managing the cooperative, SME, and trade sectors within the local government. However, there is a problem regarding the lack of publication on the estimated prices of basic commodities, which leads to overstock in the market and losses for traders, such as declining quality of basic commodities and difficulties for employees at the Cooperative, Small and Medium Enterprises, and Trade Office, especially in the Trade sector, in collecting data on changes in basic commodity prices.

Leveraging increasingly sophisticated technological advancements, a plan has been made to create a web-based information system to predict the prices of basic commodities using the Least Squares method. The primary objective of developing this system is to provide insights to traders and employees of the Cooperative, Small and Medium Enterprises, and Trade Office regarding the price movements of basic commodities, enabling them to convey better information to the public. It is hoped that the estimated prices of basic commodities will help market traders to be more efficient in planning the supply of basic commodities based on the existing price estimates and achieve the expected profits. However, it is important to note that these price predictions are only indicative, and traders should conduct thorough research and analysis before making any decisions.

Wrong decisions could lead to losses such as unsold products. Therefore, traders can utilize the distribution of fluctuations in basic commodity prices provided by the Cooperative, Small and Medium Enterprises, and Trade Office and conduct regular evaluations to reduce the risk of failure.

Research conducted by [4] introduces a system designed to predict commodity prices. This system is effective in recording price fluctuations in the Bau Bau traditional market. The web application was designed to project the prices of basic necessities using the ARIMA Box-Jenkins method [5]. This research involves analyzing five basic food varieties from five different markets in Pontianak, observing data from January 1, 2015, to December 31, 2015, and aims to predict prices in the next two days. The comparison results between the prices predicted using the ARIMA Box-Jenkins method and actual prices on January 1, 2016, show a high level of accuracy, with an accuracy percentage for chicken meat at 99.67%, rice at 99.98%, chili at 96.21%, soybeans at 100%, and carrots at 99.11% [5]. Another study conducted by [6] aims to create a desktop application that projects future rice prices for the Sukoharjo area. The Exponential Smoothing Winters method was used in the development of this application to ensure accurate price estimates by considering seasonal trends and variations. This application, built using VB.NET, is designed to help traders, farmers, and consumers plan their activities more efficiently, equipped with graphical visualization features and prediction result reports. Users can easily visualize price estimates based on the Exponential Smoothing Winters method and generate detailed reports for further analysis. The system's calculation results were compared with manual calculation results, and both methods produced the same values [6].

The main difference from previous research is that this study prioritizes the development of a web-based basic commodity price prediction system for the Cooperative, Small and Medium Enterprises, and Trade Office by utilizing the Least Squares method. This method uses existing basic commodity price data to forecast prices for the next few days. The aim is to provide accurate estimates of basic commodity prices in the future. This change is important because basic commodity prices often fluctuate or change, influenced by various factors such as scarcity of basic commodities, limited availability, and crop failure due to extreme climate conditions. Therefore, it is challenging to predict future staple food prices accurately. This system uses the Least Squares method to estimate basic commodity prices to help traders and employees of the Cooperative, Small and Medium Enterprises, and Trade Office make decisions regarding data on fluctuations in basic commodity prices that change daily.

II. METHODS

A. Research Methods

Data collection in this study uses an approach *Research and Development* (R&D). R&D is a research strategy that aims to create and test product effectiveness [7]. This method involves a series of systematic steps, namely:

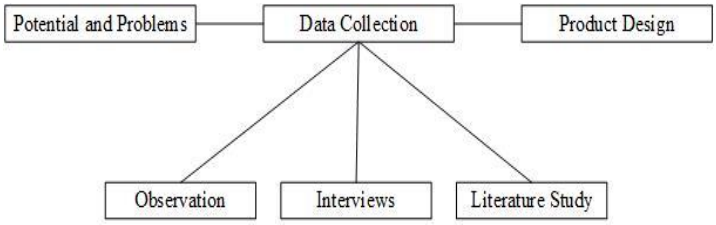

Figure 1. Method Research and Development (R&D)

1) Potential and Problems: At this stage, researchers have conducted initial studies at the Department of Cooperatives, Small and Medium Enterprises and Trade to explore the potential and obstacles faced.

2) Data Collection: in the data collection process, three stages will be carried out as follows;

- Observation is an observation, observation is carried out in a tactical system which is carried out through eye sight of the place/object of research [8]. Regarding this matter, the author visited the Department of Cooperatives, Small and Medium Enterprises and Trade to collect the necessary information.
- Interviews were conducted to obtain the required data [9]. In this context, the author interviewed Mr Harbet Aruan, S.Pd, MH, Head of Department at the Department of Cooperatives, Small and Medium Enterprises and Trade. In the interview, Mr. Harbet discussed the advantages and disadvantages of the service.
- Literature study is carried out by searching for sources and constructing them from various sources, for example books, journals and research that has already been carried out. Library materials obtained from various references are analyzed critically and must be in-depth in order to support propositions and ideas [10].

3) Product Design: Product designs are prepared with the aim of providing appropriate and efficient solutions to identified problems.

B. System Development Methods

At this stage the author chooses a system development methodology called *Rapid Application Development* (RAD), namely an object-oriented approach to system development that is much faster and produces results of better quality compared to the results achieved through traditional cycles [11]. The stages of the system development method are as follows.

1) Requirement Planning: At this stage the author carries out a series of observation and interview activities to determine the objectives and information needs to support the creation of the application or system being developed [12]. This stage requires an active role from both the author and parties in the Department of Cooperatives, Small and Medium Enterprises and Trade of Pematang Siantar City.

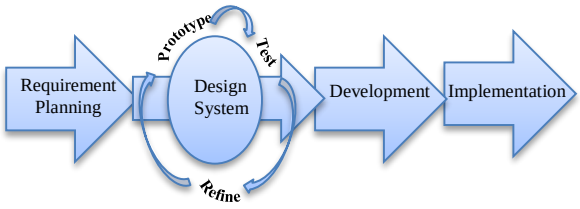

Figure 2. Method Rapid Application Development (RAD)

2) Workshop Design RAD: At this stage, the proposed system design is carried out to better understand the requirements and conduct initial analysis. The purpose of this system design is to plan how to build and operate the system so that it can meet identified needs and solve existing problems effectively [13]. This application modeling was carried out using Unified Modeling Language (UML).

3) Implementation: At the implementation stage, the results of this research are planned to be applied to develop a price prediction system for staple foods based on the website of the Department of Cooperatives, Small and Medium Enterprises and Trade. This system is based on a pre-built process by design interface. Then, the system was tested using the black box testing method and the results were compared with manual calculations.

III. RESULTS AND DISCUSSION

Based on observations and surveys conducted at the Department of Cooperatives, Small and Medium Enterprises and Trade, data on price fluctuations of basic commodities was collected from August to December 2023. This data shows the daily price fluctuations of basic commodities observed during working days. The following is observation data obtained from the Department of Cooperatives, Small and Medium Enterprises and Trade.

TABLE 1.
OBSERVATION DATA

No	1-Aug	2-Aug	3-Aug	4-Aug	…	11-Des
Nail balam rice	13500	13500	13500	13500	…	14500
Jokong rice ir64	12500	12500	12500	12500	…	13500
Bulog medium rice	10000	10000	10000	10000	…	11500
Granulated sugar	14000	14000	14000	14000	…	18000
Simple packaging of noodles	16000	16000	16000	16000	…	17000
Yellow bulk oil	14000	14000	14000	14000	…	13500
Blue triangle flour	16000	16000	16000	16000	…	14000
Twin chakra flour	17000	17000	17000	17000	…	16000
Key flour	15000	15000	15000	15000	…	15000
Pure beef	130000	130000	130000	130000	…	130000
Broiler chicken meat	21000	20000	20000	20000	…	25000
Village chicken meat	70000	70000	70000	70000	…	70000
Broiler chicken eggs	1800	1800	1800	1800	…	1800
Village chicken eggs	3000	3000	3000	3000	…	3000
Curly red chilies	22000	26000	26000	26000	…	58000
Green cayenne pepper	28000	30000	28000	30000	…	54000
Local angry onions	28000	28000	28000	28000	…	32000
Garlic	40000	38000	36000	36000	…	14000
Tomato	9000	10000	10000	10000	…	12000
Flag sweetened condensed milk	13000	13000	13000	13000	…	14000
Indomilk sweetened condensed milk	19000	19000	19000	19000	…	13000
Indomilk powdered milk	38000	38000	38000	38000	…	38000
Dancow powdered milk	42000	42000	42000	42000	…	44000
Fine salt	8000	8000	8000	8000	…	8000
Ex-imported soybeans	15000	15000	15000	15000	…	16000
Local soybeans	14000	14000	14000	14000	…	16000
Peanuts	26000	26000	26000	26000	…	28000
Mung beans	23000	23000	23000	23000	…	25000
Indomie chicken curry	3000	3000	3000	3000	…	3000
Salted fish/peto anchovies	105000	105000	105000	105000	…	95000
Dencis fish	40000	40000	40000	40000	…	32000
Bloated fish	45000	48000	48000	48000	…	50000
Corn	10000	10000	10000	10000	…	7000
Nail balam rice	13500	13500	13500	13500	…	14500

Based on observation data from the Department of Cooperatives, Small and Medium Enterprises, it can be seen how much the price of each item changes on the market every day. To predict future price changes based on the data received, you can find out trends in changes in prices of basic commodities based on the data received. To analyze price change trends, the available data is analyzed using the method *Least Square*.

A. Application of the Method Least Square

Method *Least Square* (Least Squares) is often considered the best method for determining the most precise value of an unknown quantity, especially in relation to one or more series of observations or measurements [14]. Purpose of implementation *Least Square* is to find patterns *trend* closest to most of the data points. Linear regression uses the method *Least Square* to find the trend pattern that best fits a set of data points (x,y). Pattern *trend* this can be used to predict the y value that corresponds to the new x value. To apply the method *Least Square* can use the equation:

$$Y = a0 + (bX) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [18]$$

$$a = \bar{a}nd - (b \times \bar{x})$$

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{(x - \bar{x})^2}$$

With:
AND = Estimated Trend Value
X = Time Variable
a = Trend Base Value
b = Average Trend Growth

Application of the method *Least Square* Based on existing data, the stages are as follows:

Determine the b value, as an example of applying the formula to nail balam rice:

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2}$$

$$b = \frac{(1-43)(13500-14218) + (2-43)(13500-14218) + \cdots + (85-43)(13500-14218)}{(1-43)^2 + (2-43)^2 + \cdots + (85-43)^2}$$

$$b = \frac{727500}{51170} = 14.22$$

Determine the value of a, as an example of applying the formula to nail balam rice:

$$a = \bar{a}nd - (b \times \bar{x})$$
$$a = 14218 - (14.22 \times 43)$$
$$a = 13606.3$$

Determine the forecasting value for the first nail balam rice ingredient:

$$Y1 = a0 + (bX)$$
$$Y1 = 13606.3 + (1 \times 14.22)$$
$$Y1 = 13620.52$$

TABLE 2.
IMPLEMENTATION RESULTS LEAST SQARE ON DATA

Material Name	a	b	Y1
Nail balam rice	13606.3	14.22	13620.52
Jokong rice ir64	12719.33	24.12	12743.45
Bulog medium rice	10282.35	19.70	10302.05
Granulated sugar	13560.08	35.40	13595.49
Simple golden oil	15450.42	-6.51	15443.91
Yellow bulk oil	13426.89	13.46	13440.36
Blue triangle flour	16425.21	-17.82	16407.39
Twin chakra flour	17336.13	-14.66	17321.48
Key flour	15000	0.00	15000.00
Pure beef	130794.1	-8.89	130785.2
Broiler chicken meat	25338.66	41.92	25380.57
Village chicken meat	70000	0.00	70000.00
Broiler chicken eggs	1777.941	0.23	1778.17
Village chicken eggs	3000	0.00	3000.00
Curly red chilies	33778.15	213.91	33992.07
Green cayenne pepper	26821.85	386.63	27208.48
Local angry onions	20684.03	38.26	20722.30
Garlic	34800	-44.05	34755.95
Tomato	12731.09	-25.21	12705.88
Flag sweetened condensed milk	12336.97	23.63	12360.60
Indomilk sweetened condensed milk	20275.63	-105.18	20170.45
Indomilk powdered milk	37099.16	12.19	37111.35
Dancow powdered milk	41574.79	35.06	41609.85
Fine salt	8000	0.00	8000.00
Ex-imported soybeans	14787.39	17.53	14804.92
Local soybeans	13451.26	32.19	13483.45
Peanuts	25894.12	14.50	25908.62
Mung beans	22352.52	27.78	22380.30
Indomie chicken curry	3000	0.00	3000.00
Salted fish/peto anchovies	106848.7	-27.95	106820.7
Dencis fish	37239.5	-30.19	37209.30
Bloated Fish	44963.03	-23.49	44939.53
Corn	10267.23	-9.50	10257.73

The table above shows all the a and b values from the data obtained, and applies them to get the first prediction from the model *Least Square* what you get.

B. System Design

This stage is a critical stage of the software development cycle that transforms the concepts and specifications developed during the analysis phase into a more detailed technical design. During this stage, the development team carefully designs various aspects of the system, including system architecture, user interface, database structure, and other system components. The system design stage ensures that all aspects of the system are properly considered.

1) Use Case Diagram is a diagram that describes the relationship between actors and systems [15]. This diagram highlights how the system functions from the user's perspective, and shows the interrelationships between the user and the system. Below is Use Case Diagram to design this system:

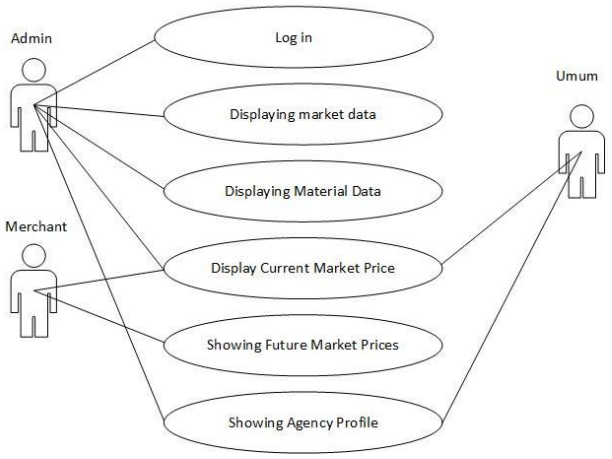

Figure 3. Use Case Diagram Plan System

The example of using the design system above shows that there are three actors in this system. This means that the management team includes employees from the Department of Cooperatives, Small and Medium Enterprises and Trade. Trading is carried out by market traders in Pematang Siantar City and is usually filled by the people of Pematang Siantar City. The diagram above also shows the respective access that each actor has.

2) Activity Diagram; made using Unified Modeling Language (UML) to talk about computer work and how things move in an organization[16-20]. This diagram visually depicts the sequence of actions and steps in the process, including the options available and the possible outcomes of each decision.

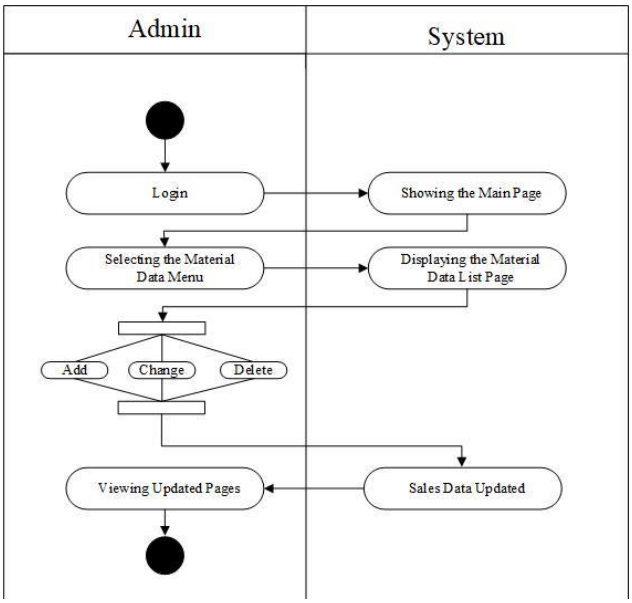

Figure 4. Activity Diagram Material Data

From *diagram activity* The above shows the process of processing basic material data in the system. *Activity diagram* Price predictions describe the process steps carried out by users, whether admins or traders, to determine the estimated market price of a basic commodity in the future. Below is *activity diagram* price prediction in design systems:

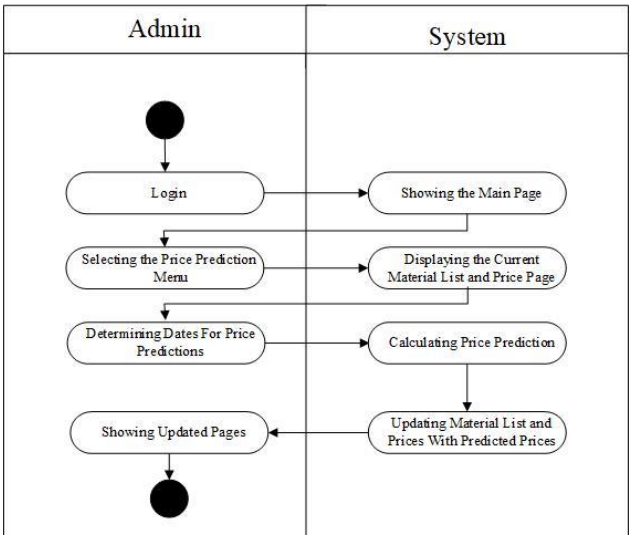

Figure 5. Activity Diagram Price Prediction

3) Class Diagram is an element of Unified Modeling Language (UML) which visualizes the static composition of a system. This diagram illustrates the existing classes, the attributes contained in them, and the relationships between classes.

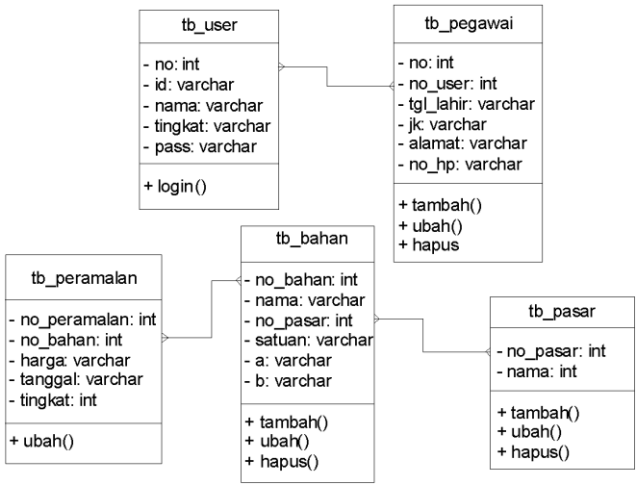

Figure 6. Class diagram Plan System

Based on the diagram mentioned, there are five classes that interact in the design system: User, User, Employee, Forecasting, Material, and Market.

C. Implementation

The next stage is implementation. In the implementation stage, program coding is carried out. The results of the coding program are as follows:

1) Page Login: is the initial page when the program is run. On this page, users can enter their username and password to enter the system.

2) Home Page (Dashboard): is the page that is displayed when the user enters the system after successfully logging in. The main page can be seen in the image below.

Figure 7. Dashboard (Home Page)

3) Profile Page User: Profile Page User is a page used to display user information or user, this page is the first page in the main page menu. There are several columns that must be filled in to display the user name, namely full name, address, gender, date of birth and cellphone number. The user profile page can be seen in the image below.

Figure 8. Profile Page User

4) Market Data Page: is a page that can display several things that are currently operating around the Pematang Siantar City area. This page is the second page in the main page menu. On this page there are also several buttons to change and delete if market data changes. This page allows users to manage existing market information. The market data page can be seen in the image below.

Figure 9. Market Data Page

5) Material Data Page: is a page that displays several basic material data with basic material prices. This page is the third page in the main page menu. This display is also equipped with several buttons to change and delete material data in the system if there are changes to the material data. The material data page can be seen in the image below.

Figure 10. Material Data Page Display

6) Current Price Page: is a page that displays several basic materials along with the prices of the materials in the current system after price predictions have been made on the price forecasting page. This page is the fourth page in the main page menu. The current pricing page can be seen in the image below.

Figure 11. Current Price Page

7) Price Forecasting Page: is a page that functions to display a list of estimated prices for basic materials that will be made. This page is the fifth page in the main page menu. On this page you can also display a calendar so you can choose which date the price of basic commodities will be predicted, then you can click the check button so that the results of the price prediction will appear at the time the user wants. The price forecasting page can be seen in the image below.

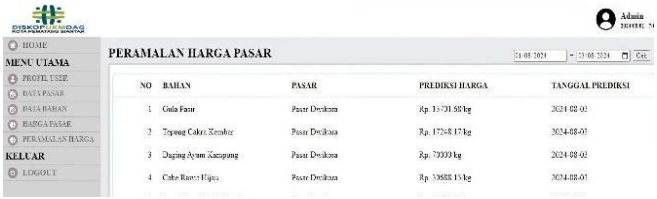

Figure 12. Price Forecasting Page

Based on the research carried out and the system that has been created, an evaluation of the forecasting model was carried out by comparing the system forecasting results with the original prices on the market at that time, the following results were obtained:

TABLE 3.
COMPARISON BETWEEN FORECASTED SYSTEM RESULTS AND ACTUAL MARKET PRICES

Name of goods	Original Price	Pediction Price	APE
Nail balam rice	14500	15511.78	6.98%
Jokong rice ir64	13500	15951.41	18.16%
Bulog medium rice	11500	12941.85	12.54%
Granulated sugar	18000	18339.08	1.88%
Simple packaging of noodles	17000	14565.06	14.32%
Yellow bulk oil	13500	15257.45	13.02%
Blue triangle flour	14000	13983.87	0.12%
Twin chakra flour	16000	15327.71	4.20%
Key flour	15000	15000	0.00%
Pure beef	130000	129567.3	0.33%
Broiler chicken meat	25000	31165.54	24.66%
Village chicken meat	70000	70000	0.00%
Broiler chicken eggs	1800	1810.141	0.56%
Village chicken eggs	3000	3000	0.00%
Curly red chilies	58000	63939.46	10.24%
Green cayenne pepper	54000	81336.68	50.62%
Local angry onions	32000	26116.95	18.38%
Garlic	14000	28544.9	103.89%
Tomato	12000	9126.06	23.95%
Flag sweetened condensed milk	14000	15577.07	11.26%
Indomilk sweetened condensed milk	13000	5129.71	60.54%
Indomilk powdered milk	38000	38854.52	2.25%
Dancow powdered milk	44000	46183.49	4.96%
Fine salt	8000	8000	0.00%
Ex-imported soybeans	16000	17346.77	8.42%
Local soybeans	16000	18151	13.44%
Peanuts	28000	28025.62	0.09%
Mung beans	25000	26964	7.86%
Indomie chicken curry	3000	3000	0.00%
Salted fish/peto anchovies	95000	102712.1	8.12%
Dencis fish	32000	32771.38	2.41%
Bloated fish	50000	40464.72	19.07%
Corn	7000	8851.73	26.45%
Mean Absolute Persentage Error (MAPE)			14.20%

Based on the table above, the results of the system evaluation were carried out using the method *Mean Absolute*

Persentage Error (MAPE) received an error percentage of 14.20%, which is still quite low so it can be concluded that the system can predict market prices quite well.

IV. CONCLUSION

This research succeeded in developing an effective web-based price prediction system for basic commodities using the method *Least Square*. This system provides significant benefits for departments, traders and the community in managing and planning supplies of basic commodities. With a MAPE value of 14.20%, this system is proven to have a fairly good level of accuracy, so it can be relied on to predict future fluctuations in prices of basic commodities. Thus, the application of the method *Least Square* In this basic material price prediction system, it can be an effective solution to overcome the problem of price uncertainty in the market and help in making better decisions.

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